

Analysis of Civil Helicopter Accidents

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NASA formed the Aviation Safety Program in mid-1997 to respond to the ambitious safety challenge posed by President Clinton. To guide the development of a safety investment strategy for the helicopter element of this program, a team of experts, drawn from helicopter manufacturers, operators, and governmental agencies, was formed and tasked with analyzing representative fatal helicopter accidents to identify prevention opportunities. The 34 accidents analyzed included a range of vehicle makes and models, missions, flight phases, types of operation, and accident characteristics. Using information contained in the official National Transportation Safety Board accident dockets, the team developed a sense of what happened (the chain of Events), identified issues or problems that might have existed with the aircraft, maintainers, environment, pilot actions, and air traffic control, and the quality of the information in the report itself (the Problems), and hypothesized what might have prevented an accident entirely or at least mitigated its severity (Solutions).

On average, 16 Events were identified per accident, ranging from 5 to 33 Events across accidents. To illustrate repeating patterns observed in the accidents reviewed, 14 representative (but hypothetical) scenarios were described. These will be made available to operators for training and safety meetings. Eventually, the written narratives will be accompanied by graphic recreations to illustrate the important points even more clearly.

The number of Problems identified in the 34 accidents ranged from 3 to 21, averaging 16 per accident. Because similar Problems occurred in several accidents, a coding system was developed to group entries into 14 categories and 58 subcategories. Examples of categories include preflight planning, safety culture, maintenance, training, pilots' judgments and actions, communications, situation awareness, and the failure of helicopter parts or systems. Postcrash survivability problems included vehicle crashworthiness, restraint systems, postcrash fires, sinking, or capsizing, and delayed rescue.

There were an average of 13 Solutions suggested per accident, ranging from 4 to 25 across accidents. Some of the solutions were available or emerging

technologies, whereas others addressed nontechnological solutions, such as changes in procedures, training, or attitudes, or broader issues, such as the need for more complete accident investigation information. Since similar interventions were suggested for different problems and accidents, a coding scheme was developed to group Solutions into 8 categories and 54 subcategories. Improving the information available in the cockpit to enhance pilot situational awareness was suggested as a solution in many accidents. Examples included enhanced/synthetic vision systems, moving maps with weather and terrain overlays, possibly coupled with sensor data, decision aids, and hazard detection and warning. To be effective in reducing the overall fatality rate, however, such technology solutions must be cost-effective, certifiable, and capable of being retrofitted to the existing fleet. Improved preflight planning might have prevented other accidents. In several accidents, the responses of pilots to emergencies were delayed because they were not aware that a problem was developing, did not recognize the nature of the problem, or did not know the correct way to resolve it.

Real-time performance monitors, health and usage monitoring systems (HUMS) and associated technologies offered potential solutions. In more than half of the 34 accidents, those related to equipment failures and malfunctions might have been avoided had HUMS been available for either on-condition maintenance or improved cockpit warnings. The potential benefits of real-time performance monitors and pilot aids, such as envelope-limiting, were discussed as well. Maintenance was another area that received considerable attention; in one-third of the accidents the team felt that improved maintenance procedures or better supervision of maintainers might have prevented subsequent part or system failures that contributed to a fatal accident. The indirect benefits of an improved "safety culture" were proposed as a means of breaking a fundamental link in the chain of events that led to several of the accidents analyzed. Improved initial, recurrent, and transition training was identified as a potential solution in many

of the accidents reviewed. Finally, ways of improving postcrash survivability and accident and incident databases were proposed.

Using databases that captured the output of the accident analysis sessions, team members developed summary definitions of the types of Problems and Solutions found and nominated safety investments that should produce the greatest safety benefits.

These represent the most promising Solutions grouped into research areas. The results of this helicopter accident analysis effort have been presented to industry and are available in a report.

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Simulation Motion Requirements in Coordinated Maneuvers

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If a pilot does not feel a lateral acceleration during a roll maneuver, the maneuver is said to be coordinated. During these maneuvers, the ball on the cockpit turn-and-slip indicator is centered. To accurately represent these coordinated maneuvers in a flight simulator, the motion platform must translate laterally when it rolls. However, most simulators do not have enough lateral displacement available to maintain coordination. As a result, the pilot feels an inappropriate, or false, lateral acceleration in the simulator. This study examined the effect of this false simulator cue. In addition, the effort suggested a criterion for simulator manufacturers and users that can be used to select the required size of future simulators. In the study, pilots flew a helicopter model in the world's largest displacement flight simulator, which is located at Ames Research Center. The large displacement of this unique simulator allowed coordinated maneuvers to be flown as a baseline. Subsequent reductions in the commanded roll and lateral simulator displacements allowed the examination of the false cueing effects. Measures of pilot-vehicle performance and pilot workload quantified the effect of these reductions in displacement.

The figure shows three fidelity regions superimposed on the percentage of full-roll motion versus the percentage of full-lateral motion. High fidelity means that the simulator motions felt like those of real flight. Medium fidelity means that the simulator motions were noticeably different from flight, but not objectionably so. Low fidelity means that the simulator

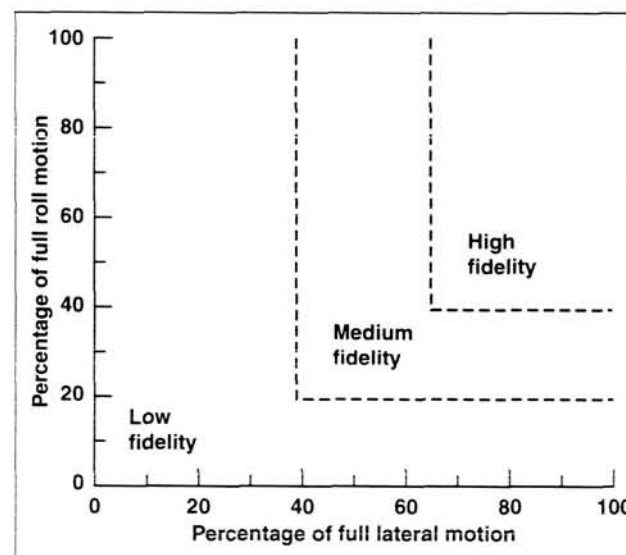


Fig. 1. Three fidelity regions superimposed on the percentage of full-roll motion versus the percentage of full-lateral motion.

motions were both noticeably different from those of flight and objectionable. Since medium fidelity is desired as a minimum, the criterion indicates that simulators should provide at least 20% of the full-roll motion and 40% of the full-lateral motion.

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